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EDITORIAL

Work on Tobacco in the College of Agriculture.

The last school year witnessed a very much greater amount of work done on tobacco in the College of Agriculture than any previous year. Our Dean's report on this crop, published in our last issue, could not include a statement of the results obtained in last year's tobacco work, because it was prepared at the middle of the year. Since then there have been brought to completion three important pieces of investigation on tobacco, which we are publishing in this number. The students in Agronomy III had extensive tests and selections of six or seven varieties of the best tobaccos in the world. The Agronomy V class performed reciprocal crossings of all these different varieties, so that we now have ready for the next season's planting seeds of at least 30 different kinds of hybrids, from about 600 individual plants. The completion of a small tobacco curing house before the time of harvest made possible the extensive cultures and curing work of last year.

One of the most conspicuous features of last year's work on tobacco was the holding of a tobacco exposition, under the auspicies of the Agronomy III class, in which were exhibited different grades of cured leaves of different varieties grown at the College. The exhibition was held in the tobacco house during the last days of March, and attracted not a little attention while still at the College. Among those who visited this exhibition was the Collector of Internal Revenue, who recommended that the exhibit be moved to Manila, where it could be examined by a greater number of persons who might be interested in tobacco work. Accordingly the exhibit was taken to Manila, in charge of Messrs. Paguirigan and Cagurangan, and set up in the main corridor of the Bureau of Internal Revenue Building. Here it attracted a great deal more attention, and was visited by nearly all tobacco men in Manila, as well as many public officials, and by many from the principal tobacco regions of the Islands.

Just as last year, it seems to be the general opinion that the exhibit constituted a clear demonstration of the possibility of growing fine wrapper in any quantity that might be desired, provided that the proper strains of tobacco be used and the right methods employed in the growing and preparation. Again, as last year, offers were made of ₱1.50 to ₱2.00 per kilo for the best grades of this tobacco. The point was made as clear as possible that these results had been obtained after long adaptation to the peculiar conditions existing at Los Baños, and that they could not be translated in their entirety to the northern tobacco regions, but that it would be necessary to repeat such work from the beginning in those regions.

Immediately following this exhibition in Manila, Professor Baker proceeded, in company with a commission from the Bureau of Internal Revenue, to investigate the conditions surrounding tobacco production in the Cagayan Valley. He was accompanied in this expedition by Messrs. Paguirigan and Cagurangan, who will probably remain in the Valley employed in this work. This Commission has returned and has presented to the proper authorities a detailed report on the tobacco work of the Valley. It has recommended various ways in which the tobacco work of Cagayan may be improved, and has already accomplished, in conjunction with the Bureau of Forestry, a very important new arrangement of forest regulations whereby the common farmers of the Valley will be able readily to obtain timber for the construction of their curing sheds. This alone will result in great advantages to the Valley for the reason that the curing sheds as now built are entirely inadequate for the proper handling of the tobacco crop of Cagayan and Isabela.

SUBSCRIPTION PRICE RAISED TO ₱3.00.

The Philippine Agriculturist and Forester has finished its fourth volume, and very materially increased the amount of material published in each year, without, up to the close of the last volume, being obliged to change the subscription price from ₱2.00, the amount originally charged for a volume of about 200 pages. Volume IV was smaller than we would have liked to have it, and contained less illustrations, because it was impossible to enlarge it at the old subscription price. There is material hitherto unpublished for want of space, sufficient to fill fully 150 pages. There are also the theses of the last graduating class, of which three are published in this issue, and there are other papers of great interest and importance which we should publish this year. Altogether, the material now awaiting publication is sufficient to fill a volume of 360 pages. The cost of printing, for reasons which every publisher at least has been made to feel and respond to, is greater for each page than it was two years or five years ago.

For these reasons, we have been compelled to raise the subscription price of Volume V from ₱2.00 to ₱3.00. Subscribers away from the college whose subscriptions have been accepted at ₱2.00 will receive the volume at that rate. We trust that it is unnecessary to call attention to the fact that subscribers to the present volume at ₱3.00 will receive materially more for each peso than did old subscribers at the rate of ₱2.00. We trust that our subscribers are finding the magazine worth receiving and reading, and that we will continue to receive their support.

The Production of Cigar Wrapper Tobacco under Shade in the Philippines

By Domingo B. Paguirigan y Amalingan

Thesis presented for graduation from the College of Agriculture, No. 55.

Introduction

The idea of growing tobacco under artificial shade is very recent. In Florida an attempt was made to introduce Sumatra tobacco about the year 1896; but the first efforts, in spite of the apparent favorable climatic conditions, as well as suitable soil, were unsuccessful. By chance, however, it was found that this kind of tobacco thrived well in new land, and what proved more important was the fact that when trees were left standing in the new fields the plants shaded by the trees were far superior to the plants not so shaded.

The first steps taken in the use of artificial shade followed immediately as a result of this discovery. Lath frames supported on posts were first experimented with and the results obtained therefrom were so gratifying that almost simultaneously a cheesecloth cover, also supported on posts, was tried, with a far more satisfactory result.

The favorable experiences in Florida at once drew the attention of the officials of the Connecticut Agricultural Experiment Station, and jointly with the Bureau of Soils they introduced this artificial shade culture into the state of Connecticut. In the report of that station in 1912 the following conclusions were announced: "No further evidence is required to demonstrate that tobacco of Sumatra type can be grown in Connecticut, which is equal in all respects to the average imported Sumatra."

Accordingly the other tobacco-raising states followed the example of Connecticut, and the culture has extended beyond the United States, so that even Cuba and Porto Rico are practicing it on an extensive scale. Up to the present, however, this method has not been practiced in the Philippines. What probably accounts largely for this indifference is the absolute absence of adequate experimental results. The attempt of the Bureau of Agriculture to experiment along this line was unfortunately frustrated by typhoons.

The object of this present work may be considered as the testing under shade of the native Cagayan, Tirona Hybrid, and the acclimatized foreign varieties,—Turkish Lowland, Vuelta Abajo, Sumatra and Texas Cuban,—to find out in a preliminary way what their respective possibilities are in the production of wrapper leaves under local conditions, as compared with leaf produced in the open field.

The following table is derived from the report on the Foreign Commerce of the Philippine Islands, Bureau of Customs (July-December, 1913; January-December, 1914):

Import of leaf Tobacco.

Year	*Quantity*	*Value.*
1912.....		₱35,349
1913.....	18,061 kilos	37,241
1914.....	15,806 "	47,996

It is thus perfectly plain that the importation of leaf tobacco wholly for wrapper, that might just as well be produced locally, is rapidly growing. Philippine haciendas are capable of growing leaf tobacco which can meet all the requirements of first class wrapper. Indeed certain regions of the Philippines have all the natural advantages for wrapper growing. The trouble lies only in the neglect, on the part of those directly concerned, to apply modern methods. Besides, the general attitude of the native tobacco farmer in the Philippines is ultra-conservative.

The surest way of producing a characteristic native wrapper variety is by seed selection alone or by the combination of hybridization and selection and the production of such strains under conditions likely to produce thin, fine leaf, together with the employment of proper methods of curing and fermentation. Hybridizations were undertaken with success by Mr. José P. Tirona, a graduate of our College, in 1914. Mr. Tirona produced a hybrid between Cagayan and Connecticut Broad Leaf, which, according to one of the leading tobacco factories in Manila, La Germinal, is a "valioso descubrimiento." It remains only to find out whether it would pay to grow the native tobacco or any other standard foreign wrapper varieties under shade in the Philippines. Later on, the improvement of the native tobacco by selection should be actively undertaken.

So far there has not been any real attempt to investigate thoroughly the phenomena connected with shade culture so that the growers practicing it might be guided by definite physiological facts. The grower is satisfied so long as he gets a product which, on the average, not only pays for the extra expenses involved but also brings more revenue.

Dr. H. Hasselbring, while conducting some experiments during the winter of 1908-1909 in Cuba, claimed to have found the tobacco plants grown in the open absorbed about 28 per cent more water than those grown under shade; and that the plants which absorbed and transpired the greater quantity of water contained the smaller percentage and the smaller absolute quantity of ash.

Some of the conclusions reached by A. Sutzer in 1914 show that abundant sunlight, high temperature, liberal nitrogen manuring, and sparing use of water in the soil, produce a large per cent of nicotin; also that direct sunlight favors a high potassium, but a low chlorine, content.

As to what degree of shading suits the purpose best, the Connecticut Agricultural Experiment Station in 1906 found out that, under Connecticut conditions, cloth containing 12 threads to the inch produces a higher yield and a better quality of tobacco than that which contains 8 threads to the inch.

The present work is concerned largely with the problem from the growers' standpoint, as related to Philippine conditions. Its purely physiological aspect is touched upon only incidentally.

The cultures were located on a very slightly inclined piece of ground by the Molawin River, some forty feet above the river level. The soil is rather heavy, and although it has long been cultivated with corn, rice, or cane, it had never been used before for tobacco. The soil is neither gravelly nor sandy. However, the mere fact that the soil is not specially adapted for growing wrapper markedly served to show the effect of the cheesecloth cover. According to Whitney, of the Division of Soils, United States Department of Agriculture, "as a rule, the lighter the texture (of soils)—that is, the less clay they contain—the thinner the texture of the tobacco leaf and the more elastic, pliable and better the wrapper it will make." The alluvial soils formed by the yearly overflow of the Cagayan River are light and sandy enough to insure the production of wrapper tobacco, but the fact that they are extraordinarily rich in plant food causes the tobacco to grow so luxuriantly that on the average the product departs considerably from the ideal wrapper, which should have little body and but little flavor.

The seed used in the present work included four acclimatized foreign varieties, namely, Texas Cuban, Turkish

Lowland, Vuelta Abajo, and Sumatra. Native Cagayan and Tirona Hybrid (a cross between Cagayan and Connecticut Broadleaf), were also used. The object of including so many varieties was to find out which ones would profit best by shade culture and which ones would not. With the exception of the Cagayan, all the seed used were selected in their first generation (F) by Mr. J. C. Miraflores, in connection with his last year's class work in Agronomy III. The Cagayan came directly from the Cagayan Valley. It is selected in the ordinary local sense of the word, but as it was not bagged at all during inflorescence it undoubtedly represents various strains.

The seeds were planted in carefully prepared wooden flats, September 25, 1915. The flats are 36 by 46 centimeters and 8 centimeters deep. This size makes handling easy, a fact especially to be considered as the flats were moved quite frequently from one place to another. The kind of weather we had this season decidedly emphasized the need of conveniently handled flats. Strong winds and heavy rains occurred very unexpectedly, which necessitated the instant transfer of the seedlings into an adequately protected shelter. Kerosene boxes can easily be converted into flats.

The seedlings were pricked, beginning October 5th, and until the 19th. As pricking is a phase of culture still unknown to the tobacco grower of the Islands, I might explain this simple but valuable process in this connection. Pricking simply consists in transplanting at convenient distances the crowded young seedlings into new flats or newly prepared seed beds. To give the seedlings more room in this experiment, they were planted four centimeters apart each way and this proved to be a sufficient distance for the purpose. The seedlings given more space thrived more freely and uniformly. At the time of pricking the first pair of true leaves had begun to develop. Pricking began with the sixth day after germination. Through pricking, the seedlings produced proved more uniform and stocky than the unpricked ones.

In the flats two distinct layers of soil materials were used, namely the upper, of rich, sieved, somewhat sandy, loamy soil, and the lower, of more or less well rotted compost, chiefly manure.

The Shade Tent

The shade tent was built to cover an area of 774 square meters or about one-thirteenth of a hectare. Bamboo posts ranging from 8 to 12 cm. in diameter and 3½ meters in length were used. These posts were set in the ground to a depth of 90 centimeters and at points 3¼ meters each way. The posts were braced on the ground at the corners only with bamboo props. Guys of number 14 wire were passed lengthwise and crosswise along the tops of the rows of posts. The guys were stapled to the posts and were anchored at each end to the two extreme or last posts in the rows. To hold down the cloth, its lower edges were sewed to a wire running around the sheltered area and stapled at every post.

The cloth used for cover is not of the special weave in common use in America but is the same fabric as is commonly used in the making of mosquito nets. The cloth has a width of one yard only, so that it was necessary to employ three women from a neighboring barrio to sew the bolts together at the sides in order to render more convenient the placing of the cover. The cloth is rather too finely woven (16 fine threads to the centimeter) for the purpose, although its diffusing effect on the light is similar to that of the standard tobacco cloth.

In America the cloth used for cover is a special weave of coarse-thread cheesecloth. It has a heavily corded silage and inch-wide bands of close weave at intervals of several feet; the width is one rod, or 5.06 meters. It has only five threads, rather coarse, to the centimeter. It is usually sold for 5 7-10 centavos a meter, a difference of 1 3-10 centavos per meter as compared with the cost of the cheesecloth actually used in this work. Besides the fact that it is made of coarser and consequently stronger threads, and the fact also that it is already made very wide, the special weave serves longer and saves extra labor besides offering greater resistance to strong breezes. The cloth actually used here has been found to yield rather easily to the wind so that repair costs were incurred which otherwise would have been saved. Although there was no hard wind after the erection of the tent, the cloth at the time of removing it had been considerably torn along extended stretches so that before it can be used for the next season it will have to undergo much mending, which requires additional expense.

When the cloth was ready, it was twined securely to the surrounding wires above and below and the cover proper was fastened at every intersection of the wires. The tent being small, no allowance was made at the ends, as practiced in America, for the horses to turn during cultivation. In Pennsylvania for instance, the sides of the tents are made to slope to afford enough head room for turning the horses, allowing full cultivation to the post line. In this work, however, it was decided to make use of all the shaded ground, so that the sides of the tent had to be vertical. But during cultivation the ends were unstapled and raised so that the vacas could easily be turned at the end of the rows, as well as driven directly through the unshaded areas without turning.

Material Used.

72 bamboo posts at 25 centavos	₱18.00
½ Mile No. 14 wire	4.19
Staples, nails, twine, etc.	1.00
1226 meters unbleached cheesecloth at 7 centavos a meter	85.82
Labor—sewing cloth	13.60
Labor—erecting shelter, etc.	7.60
TOTAL	₱130.21

Although the tent was erected after the baguio season it did not escape from occasional rather strong breezes, causing actual repair expenditures amounting to ₱4.00. In case of strong winds, of course several times that sum might be required.

Before any figuring on the cost of tobacco under shade is attempted it should be taken into consideration that tent expenses should be based on the cost of a special weave of cloth, that the woman labor is therefore not normal, and that the cloth serves at least two seasons, although it is very probable that it may be of service longer than that. The tobacco cloth should be ordered directly from America, allowing 10% for freight expenses, etc.

PLANTING

Owing to the exceptionally long and very heavy rainy weather this season, and in order to keep up with the local tobacco season, the ground had to be hurriedly prepared. The ground therefore, at the time of planting, was rather lumpy and uneven. The ground had been cropped with rice last year and not fertilized. Neither was it fertilized in this experiment. The seedlings were 15 cm. to 20 cm. high at the time of transplanting.

The general method of planting followed was that for ordinary field culture.

Planting was done in rows 80 centimeters apart and 50 centimeters in the row. This close planting was decided upon in order to insure inter-shading

of the leaves and consequently the production of thinner leaves. Besides, the soil is rather heavy. Transplanting was done during the last week of November. Most of the young seedlings were washed down or buried by a storm and the result was that planting had to be repeated during the following week.

The area under shelter was divided into six plots varying in size according to the number of seedlings available at the time of replanting. With the exception of the Turkish Lowland plot, the plots were practically the same in size.

Outside the tent, plots were laid out corresponding to the number of plots inside. As a matter of fact, the outside check plots are merely direct extensions of the plots inside, so that the shaded and the open plots of one variety were linked at one end.

On account of the uneven condition of the ground, cultivation could not be begun until the tenth day after replanting, because of the danger of injuring the young seedlings. Lumps of ground might be rolled over the young seedlings as the cultivator passed or because of their small size they might be overlooked and stepped on by either the vaca or the man. This emphasizes the well-understood necessity for very thorough and perfect preparation of the soil intended for tobacco. The soil proved too heavy for the Plant Junior Cultivator so that it was necessary to use a small plow, instead, during cultivation. The ground was cultivated four times, at least one day after good rains. The last cultivation, followed immediately by garden hoe cultivation to keep the uniform distribution of soil around the plants, gave very good results, as evidenced by faster, better, and more uniform growth of the plants afterwards. Indeed, the cultivation and a rain once in a while during the most active vegetative period of the plants rendered watering absolutely unnecessary.

Topping and Suckering

The first seedlings having suffered considerably during the heavy downpour of rain referred to previously, which was followed by very dry weather, began to show signs of flowering at an undesirable height. This was especially true in the case of the Sumatra and some of the Texas Cuban. For this reason, and in order to insure the maturing of a reasonable number of leaves, such plants were topped by pinching out the flower-bud, allowing only as many leaves to remain as the plant was able to mature. Also, because the ground was not fertilized, the condition of the plants, especially those outside, was not very remarkable. Many individual plants, however, especially those planted after the baguio, were very exceptional. Seed were finally selected from the best of these. The handicapped plants were especially benefited by the topping, although topping was extended to the good plants as well, with the exception of those selected for seed.

Shortly after topping, suckers began to appear at the junction of the leaves. These suckers were removed from time to time.

Harvest

All the leaves being especially produced for wrapper, harvesting was done by priming or the act of removing or gathering the leaves singly from the stalk as they severally reach the proper degree of ripeness. It is hard to make a very definite rule as to when leaves are exactly ready to be primed. Of course it is easy to distinguish between the extremes; that is, between a green leaf and a too ripe leaf. Priming or picking the leaves is, indeed, a particular operation. It is only through experience that one can become a successful primer

or picker, and this is especially true in the production of fine wrapper. Among visible indications of ripening are a yellowish color around the edges of the leaves, especially at the tips, occasional spots on the surface of the leaf, and in fact a noticeable general change in color, to lighter. Harvesting began February 16, 1916. The sand leaves were picked first. The difference in the appearance between the leaves inside and outside was so apparent that it appeared as if the outside leaves were ripening earlier. On this account the outside leaves were always primed one or two days earlier than the inside ones, and as far as the curing results could show this scheme seemed to be satisfactory. Priming was done at intervals of one week in order to insure a uniform degree of ripeness and a more or less uniform size of the leaves. It took five primings to harvest the Sumatra, Texas Cuban, Turkish Lowland, and Vuelta Abajo varieties, whereas the Cagayan and Tirona Hybrid required six or seven.

The leaves were placed along the rows during priming, in piles as they were picked from the stalks. These piles were in turn gathered into convenient baskets called *bilaos* and then transferred to the curing house.

Curing

Priming was always done during the evening, so that, after taking the fresh weight, the leaves were allowed to wilt up to just past noon the following day, when the leaves were immediately poled. Poling of the leaves (by the Cuban method) was done by the use of a big needle and white string, which was tied at one end of a pole varying from 2 to 4 centimeters in diameter and from 2.2 to 2.5 meters in length. By driving the needle through the midrib, 84 leaves in the case of the large varieties like Tirona, and 234 in the case of the small leaves like Texas Cuban, were strung alternately back to back, so that the leaves rode alternately on the poles. Ipil-ipil (*Leucaena glauca*) was found to make a most convenient and most economical pole for the purpose. The loaded poles were then hung on uniformly distanced racks in the house for curing. The spaces between the poles varied according to the size of the leaves; the larger they were, the more space was allowed the pole.

The newly poled leaves were placed on the higher racks so that they could be more ventilated, the lower racks being below the window level. The poles, therefore, that were nearly cured were placed on the lowest racks, until the completion of curing.

The leaves were never exposed to the direct rays of the sun, so that the whole process of curing followed was a cool or natural process. The sand leaves cured much earlier than the standard leaves. Most of the sand leaves cured in one week, whereas the standard leaves required from 18 days in case of the small varieties, namely, Sumatra, Texas Cuban, Turkish Lowland, and Vuelta Abajo, to 24 days in case of the larger varieties, namely, Cagayan and Tirona Hybrid.

The management of the tobacco house depended on weather conditions. The precautions taken to secure the necessary slow and natural curing of the leaves were the closing of the windows and doors during very hot and dry days and during strong breezes or dry wind. The latter especially was found to greatly accelerate evaporation.

The time for removing the leaves from the poles was when the midribs were also cured. After taking the cured weight, the hands were then transferred into a wooden case preparatory to fermentation.

Fermentation

In the opinion of tobacco merchants a tobacco can only be judged after it is fermented, however promising and beautiful it may look in the field or in the curing house. For this reason, and because of lack of room and necessary materials in the College, it was decided to take sufficient samples to Manila to be fermented. Through the kindness of the factory manager of "La Germinal," Sr. Guido, permission was obtained for the use of the factory fermenting room and other facilities. There are two distinct courses to follow during fermentation. One proceeds to fermentation immediately after curing, and aging later, or aging may come first and fermentation later.

The latter course is universally practiced in the Philippines. The tobacco is stored in big warehouses for at least two years after being purchased. This makes the period of aging almost three years.

The fermentation of the samples taken to Manila is illustrative of the second course. This method is universally practiced in America. The samples were not dipped in a tank of water at all, because being newly cured they must contain sufficient moisture to keep them soft and almost tender. The samples after one week showed a decided change in color, fineness, and elasticity.

Effect of Shade on the Quality of the Crop

Finally, when the leaves were completely fermented, the factory manager and his assistant pronounced their opinion as they re-examined the twelve distinct samples produced. These twelve samples represented six different varieties, as grown inside and outside. The following account of the final leaf product is a reproduction of the statements made by Sr. Guido, who has been engaged in this line of work with tobacco for a very long time and who is the factory manager of one of Manila's largest cigar and cigarette factories.

On the whole, Cagayan and Tirona Hybrid gave the best results. The leaves produced outside turned out to be satisfactory and to compare favorably with, if they were not better than, the best wrapper locally produced, in color, texture, plainness, and elasticity. The leaves produced under shade, however, approached almost "the ideal," to quote Sr. Guido's own phrase. And to quote again, *"es igual, si no superior, que la Sumatra; pero nunca menos,"* (it is equal if not superior to Sumatra but never inferior).

The Sumatra both inside and outside turned out to be almost altogether unsatisfactory. The leaves grown in the open were too thick, while those shaded exhibited a great diversity of color besides being conspicuously brittle.

The Turkish Lowland gave only fair results. Under shade, it had the texture but not the color and elasticity, while in the open it had only an acceptable color.

Texas Cuban and Vuelta Abajo gave the same results. So far as merely fineness, texture and color are concerned, these qualities are possessed by these two varieties, especially when produced under shade, but the trouble really lies in their susceptibility to diseases. Practically all the leaves were spotted. Both varieties were grown and cared for just as were the Tirona Hybrid and the Cagayan, but the latter two did not suffer seriously from the same diseases, although occasionally one finds similar spots on their leaves.

On the morning of March 18, 1916, at "La Germinal," while the samples were being rebulked with the rest of the

tobacco, it happened that a Spanish tobacco man was present. He especially noted the Cagayan and Tirona Hybrid samples and observing that there were several hands of the same samples, he begged for just one to take with him, claiming that such an "hermoso tabaco" he had never seen before in the Islands.

Testing the Burning Quality of the Different Varieties Inside and Outside

In testing the burning quality of the different varieties inside and outside the following method was used. A leaf was ignited by means of a lighted cigarette and the number of seconds during which the glow produced continued was noted. The average of a number of tests was taken as a measure of the capacity for holding fire; but the variation in the results obtained, even upon a single leaf, was so great that little reliance can be placed upon the figures except in a very general way. In this method no account was taken of the area of the leaf burned and the wide differences obtained on a single leaf were due principally to the fact that frequently the ignited zone soon ceased to glow except for one or more very small streamers which continued to burn for a much longer period, thereby giving results altogether out of proportion to the true burning qualities of the leaf. It should be considered, however, that another fact which is a very possible source of error was the interference of the veins of the leaf; for it did not always happen that the glow could cross these veins except around the outer edges of the leaf.

Varieties	*Inside*	*Outside*	*No. tests*	*Remarks*
Cagayan	377 sec.	321 sec.	5	The figures cannot be relied upon as comparative by varieties because the tests were intended only to show the effect of shade on the burning qualities of the leaf.
Sumatra	18 "	10 "	6	
Texas	4 "	4 "	6	
Tirona Hybrid	278 "	253 "	5	
Turkish Lowland	8 "	8 "	4	
Vuelta abajo	9 "	9 "	4	

The above table shows that the burning qualities of only Cagayan, Sumatra, and Tirona Hybrid were improved when shaded, though not very remarkably; the other three varieties showed no response.

Effect of Shade on the Size of the Leaves

Leaf measurements were taken just before the middle standards were to be unstrung from the poles. Twelve poles from each of the six varieties inside and outside were selected, from each of which the lengths of one hundred more or less uniform leaves were measured and recorded. Abnormal leaves such as those that are exceedingly long and those very short were disregarded. The following table will show the average lengths per leaf as determined from the measurements:

Determination on the size of the Leaves.

Varieties	*Average length of leaf*		*Difference*
	Inside	*Outside*	
Cagayan	59.88 cm.	50.05 cm.	9.83 cm.
Sumatra	30.94 "	31.84 "	.90 "
Texas Cuban	37.36 "	31.32 "	6.04 "
Tirona Hybrid	59.11 "	57.38 "	1.72 "
Turkish Lowland	40.36 "	34.95 "	6.08 "
Vuelta Abajo	42.13 "	34.95 "	7.18 "

From the above table it is evident that there is usually a considerable increase in the size of the leaf when grown under cheesecloth. I have not made any physiological study to explain this fact but I believe that this must be due to the difference in moisture actually present in the shaded and in the open plots. The greater the per cent of moisture in the soil the more plant food will be available in solution, and there is no danger in the least of the plants' wilting, as enough water would be absorbed to keep up with the activity of transpiration.

In the above table it will be noticed that the unshaded Sumatra leaf is longer than the shaded one. The reason for this is that the outside plants were topped earlier and further below the flower bud. Consequently the open Sumatra plants, while producing bigger leaves on the average than those shaded, have a smaller number of harvestable leaves.

Effect of Shade on the Weight of Leaves

Determinations of the effect of shade on the weight of the leaves were based on the total number of middle standard leaves harvested. The figures in the following table represent the average weight per leaf of each plant.

Determination on the weight of Leaves.

Varieties	*Average weight per leaf*		*Difference*
	Inside	*Outside*	
Cagayan	27.57 g.	29.36 g.	2 .79 g.
Sumatra	15.24 g.	17.25 g.	2.01 g.
Texas Cuban	11.03 g.	18.78 g.	7.75 g.
Tirona Hybrid	43.18 g.	54.30 g.	11.12 g.
Turkish Lowland	20.36 g.	19.31 g.	1.05 g.
Vuelta Abajo	15.00 g.	17.60 g.	2.60 g.

The above table shows the coarser texture of the leaves in the open. The unshaded plants being always under full illumination, their photosynthetic function is normal and therefore they manufacture more carbohydrates than the plants growing under shade. It will be noticed that the shaded Turkish Lowland leaf weighs more than the unshaded one. The reason for this is the fact that more than one-half of the outside Turkish Lowland plants were planted near a spreading mango tree.

Effect of Shade on the Total Growth of the Plant

Determinations of the total growth of the plants inside and outside were made when every plant in the whole field had matured. Every plant was measured from the ground to the lowest top leaf. The figures in the following table represent the average height of the plants in each plot:

Determination of the total growth of the Plants.

Varieties	*Average height per plant*		*Difference*
	Inside	*Outside*	
Cagayan	138.12 cm.	87.74 cm.	50.38 cm.
Sumatra	97.23 "	72.72 "	24.51 "
Texas Cuban	104.20 "	94.20 "	20.00 "
Tirona Hybrid	86.20 "	73.45 "	12.75 "
Turkish Lowland	150.81 "	110.46 "	40.35 "
Vuelta Abajo	120.61 "	112.70 "	7.91 "

Thus the plants growing in the shaded plots were considerably taller than those plants in the open.

Cultural Summary

1. It pays to use selected seed.
2. Uncertain weather conditions in the Philippines require that more seed be sown in the seed beds than is actually necessary, and that unusually effective methods of protection should be employed.
3. Naphthalene powder or lemon oil will protect the sown seed from ants.
4. Pricking is a good practice for preparing uniformly stocky and strong seedlings.
5. The use of flats makes the protection of the seedlings easier, and results more sure in small plantings of 10,000 plants or less.
6. The land should be very thoroughly prepared before planting.
7. The seedlings should be planted as close as 50 cm. in rows 80 cm. apart, if wrappers are desired.
8. Frequent and thorough cultivation gives good growth.
9. Topping and suckering are essential for insuring the production of good leaves.
10. The leaves should be primed at exactly the right time.
11. Weekly priming of the leaves is a good schedule to follow after having begun to harvest.
12. Slow and cool natural curing produces fine "claro" and "colorado" colors.
13. The leaves should not be removed from the poles until the ribs also are dry or cured.
14. Harvested leaves ought not to remain too long in the wilting piles.
15. Moisture conditions in a house which can be closed can be very perfectly controlled.
16. Strong breezes or dry winds are very bad during curing.
17. If the cured leaves are to be fermented immediately, they may contain enough moisture to save the extra process of wetting the leaves before they are to be bulked.
18. After one week of fermenting wrapper leaf, it is possible to judge its color, texture, and elasticity.

Recommendations

It must be recalled, in considering this experiment as a whole, that the leaf grown outside also came out satisfactorily. That there is a difference between this leaf and the one produced inside is true and the difference is in favor of the latter. This experiment should be continued, to find out, among other things, whether this difference would be sufficient to pay for the extra expenses incurred.

This experiment is important enough to warrant its being continued. If this is done the next thing should be to raise a larger shaded crop of Cagayan and Tirona Hybrid, not only for the purpose of reaffirming the results obtained in the present work, but primarily to investigate thoroughly the commercial side of the question, Will it pay to grow shaded tobacco in the Philippines?

In the continuation of this work, efforts should also be made to secure the proper special weave of tobacco cloth; to make the tests in localities with lighter soils, and to find out also what kind of a crop a more favorable season would produce.

Conclusions

The favorable results from Cagayan and Tirona Hybrid indicate that good wrapper tobacco can be grown under shade in the vicinity of Los Baños, Laguna, in spite of a somewhat unfavorable season and a rather heavy

unfertilized soil. The four foreign varieties—Sumatra, Texas Cuban, Turkish Lowland, and Vuelta Abajo—did not show up well under the same conditions.

The observations and various determinations made on the effect of the shade on the plant itself show clearly that the general vigor of the plants, the quality of the crop, and, to a certain extent, the burning quality, are generally improved in the plants under shade.

Acknowledgements

I wish to express my obligations to Professor C. F. Baker for his valuable suggestions and criticisms throughout the progress of this work, and to Sr. J. Guido, Factory Manager of "La Germinal," for supervising the fermentation of the sample standards.

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Fertilizer Tests with Tobacco Varieties on College Soils

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Thesis presented for graduation from the College of Agriculture, No. 56

Introduction

The progress of Agriculture in the Philippines is decidedly dependent upon the real improvement of the four staple products of the Islands; namely, hemp, sugar, copra and tobacco. The last named crop occupies an important position as a money crop in the tobacco producing districts in the United States, in the Vega districts of Cuba, and in the northern provinces of the Philippines. During the period of the Tobacco Monopoly, which was established during the Spanish regime in the Philippines, tobacco was the chief source of income for the Government of the Philippines as well as for the people of the tobacco-growing provinces. At the present time this crop should receive more attention from the growers and be given more care, for it plays a large part in the agricultural economy of our country.

The following table, compiled by the Division of Statistics of the Bureau of Agriculture, shows the annual production and value of tobacco in the Philippines from 1910 to 1913, inclusive, and the amount of land under cultivation. The average value per acre is, of course, no indication of what the farmer actually receives for his crop.

Table I.

Fiscal Years	*Area Cultivated*	*Quantity Produced*	*Average Production per acre in lbs.*	*Average value of Production per acre in Dollars*	*Total Value in Dollars*
1910.....	132,510	61,744,303	466	28.53	3,780,915
1911.....	170,539	56,257,784	330	20.20	3,444,948
1912.....	140,948	65,219,646	463	28.33	3,993,728
1913.....	170,477	101,545,657	596	36.47	6,218,153

It is commonly said by many of the authorities in this line, that fertilization is a good investment, provided it is carried out properly and carefully. Fertilization promotes the vegetative growth of the tobacco plant, increases its yield, and develops the aroma, flavor, and quality of its leaf. It also serves as a means of maintaining the fertility of the land. But all of these facts are overlooked by the majority of our common farmers. They have no idea that their lands are deteriorating and becoming depleted from continuous cropping without giving back the elements or soil-food taken up by the crops. They usually follow their rice with tobacco, as practiced in the Ilocano provinces, and in the Cagayan Valley they follow their corn and rice with tobacco. They always insist on putting these methods into practice and as a result none of these crops is giving them as great returns as it should, except on annually inundated lands. This method of farming is not profitable in the long run.

It is most important that fertilization, better systems of seed selection, of harvesting, of curing and of fermenting, should be studied and put into practice by the Filipino farmers in order to increase the annual production and the quality of our tobaccos.

Previous Experiments on the Fertilization of Tobacco

The question of quality of the leaf is the first thing that every planter should take into consideration in growing tobacco. This problem has already been solved to a great extent by many of the Agricultural Experiment Sta-

tions in the leading tobacco regions of the world; namely, Ohio, Wisconsin, Texas, Cuba, and Darmstadt.

With respect to the combustibility or "burn" of tobacco as influenced by manuring or fertilization, Dr. Paul Wagner, Director of the Ducal Agricultural Experiment Station at Darmstadt, states that Prof. Nessler has found that potash exercises a highly important influence on the burning quality of the leaf of tobacco, while chlorine is deleterious. One of the tests of the quality of tobacco leaf is the duration of its glow. The results of experiments along this line which have been carried out by Prof. Nessler are tabulated as follows:

TABLE II.

Percentage of Potash	*Percentge of chlorine*	*Duration of Glow in Seconds*
4.0	0.40	25 and over
3.5	0.22	13 to 24
2.8	0.67	8 to 12
2.2	0.73	4 to 7

This table reveals the fact that with the increase of the percentage of chlorine and with the decrease of the percentage of potash the duration of glow, in seconds, is greatly diminished.

Dr. P. Wagner presents the following suggestion with respect to the proportions in which the three elements—nitrogen, phosphates and potash—should be present in a mixture of manuring generally used for the growing of leaf of high quality:

Ammonia.....3 to 4%
Potash.....8 to 9%
Phosphoric acid....2 to 4%

In the application of farmyard manure he points out that better results can be expected if it is applied in conjunction with a certain amount of commercial fertilizers; namely, nitrate of soda or sulphate of ammonia. He believes the latter to be more effective, since an excess of soda is detrimental to the burning quality of the leaves. The best and cheapest form in which potash should be applied is sulphate of potash. Farmyard manures should be so used together with any of these ingredients as to supply a sufficient amount of plant food. He also points out that farmyard manure should be applied and worked into the soil for a considerable length of time before setting the plants in the field, so that the chlorides may leach off, as they have injurious effects on the quality of the leaf.

Beyond the fact that the degree or extent of the "glowing" properties of the fermented leaves rises with the amount of potash in them, the duration of glow in the fermented leaves is much greater than in the unfermented leaves.

After all, according to Dr. Wagner, the question of combustibility of the tobacco leaf is not yet fully settled. Dry weather has been found to produce a bulky, spongy leaf which burned badly in spite of its high percentage of potash. So the extent to which the burning quality of the tobacco leaf can be influenced by potash manuring still requires further investigation.

Similar tests on the burning quality of tobacco were carried out by Otto Olson (Annual Report, Penn. State College, 1912-1913 p. 198) at the Landisville Station and his reports give the following comparative results:

TABLE III.

Point of Quality	*Scale*	*Fertilized with Manure alone*	*Fertilized with manure plus phos. acid & potash*
Quality.....	10 points	5	6
Aroma.....	40	20	25
Flavor.....	20	10	14
Burn.....	20	12	16
Yield.....	10	10	10
TOTAL.....	100	57	71

Olson repeated these tests, and found again that the tobacco from fields treated with manure, phosphoric acid and potash is superior in aroma, flavor, and burn, as shown in the table.

In Cuba, according to J. T. Crawley, Director of the Central Agricultural Experiment Station at Santiago de las Vegas, extensive experiments on the fertilization of tobacco and other crops are being carried out at the station itself as well as in other parts of the island. Stable manures had been used extensively as fertilizing material in the tobacco regions of Cuba for many years, before the commercial fertilizers came into use. Manures are still used in conjunction with the commercial fertilizers. According to the analyses performed at the Station, stable manures are poorer than the commercial fertilizer in all its important elements—phosphoric acid, nitrogen, and potash.

The manures usually contain:

Phosphoric acid	0.15 to 0.50%
Potash	0.4 to 0.6%
Nitrogen	0.4 to 0.8%

Better results can be obtained from the application of manures when used with commercial fertilizers.

As to the effect of different fertilizers on the yield of tobacco, J. T. Crawley (Central Agricultural Station of Cuba, Bulletin No. 14, page 14) has shown that a plot fertilized at the rate of 105 tons of stable manure per hectare was more productive than one fertilized at the rate of 70 tons, but when the same quantity of ingredients as existed in the manure was applied in the form of commercial fertilizer, the result was better. With the addition of chemical fertilizers to the stable manure, phosphoric acid showed more promising results than the sulphates of potash and ammonia. His general conclusion on the results of his work is that on land of good physical condition, commercial fertilizers could be used with profit in place of the stable manure, so costly in Cuba.

Similar tests on the effect of different fertilizers on the yield of tobacco have long been under way in the Ohio Experiment Station (Bulletins 161 and 172), and the following instructive results have been obtained:

1. In the experiments during two successive years (1905-1906), farmyard manure was the most effective fertilizing material for tobacco.

2. In the first year, 1905, "the greatest total yield as well as the greatest net profit was produced by a fertilizer containing nitrogen, phosphorus and potassium in approximately the same relation to each other in which they are found in farmyard manure, and in the second year, 1906, the greatest total yield was produced by fertilizer containing relatively more *phosphorus*, in proportion to nitrogen, than is found in ordinary farm manure."

J. M. Priego, in his first trial on the fertilization of tobacco, (Official Bulletin of the Philippines, April, 1894, Vol. I pp. 105-106), at Ilagan, Isabela, used horse manure, carabao dung, sheep dung, guano, "abono parsons" and ashes. His purpose in carrying out this work was to find out the effects of these materials on the height and yield of the plant.

The plots treated with horse manure and carabao dung gave better results than any others, and the latter was more effctive than the former.

In the following year (*Ibid.* Oct. and Nov. 1894, Vol. I pp. 300-332) Priego worked with both commercial and natural fertilizers, and obtained the reverse of his first results. The use of horse manure resulted in an increase of more than 62% over the control,

while carabao dung had almost no effect. No commercial fertilizers showed better results than the horse manure. Priego's results give us a hint that the natural fertilizers which are abundant in the yards and corrals or stables of every farmer, and are now wasted, could be made of immense value in the growth of the tobacco. He continued working on this line for six years, using natural fertilizers in conjunction with commercial fertilizers, and his results are published in Volumes I and III of the *Boletin Oficial Agrícola de Filipinas*.

Plan of Experiment

It had been planned to carry out this work in two distinct experiments.—First, to use horse manure alone, and the combinations of it with commercial fertilizers.—Second, to use leguminous crops alone, turned under, and the combination of these with horse manure and commercial fertilizers. In conjunction with these experiments three plots were set aside as controls, or check plots. It was also planned to use five varieties of tobacco in each plot, namely, Turkish Lowland, Sumatra, Tirona Hybrid, Vuelta Abajo, and Texas Cuban. The aim was to observe the behavior of the different varieties under the influence of these fertilizers; to measure the comparative effects of the fertilizers on their vegetative growths, yields and qualities.

The Land and Its Preparation

The land selected for this purpose is located northeast of the Physics Laboratory. It is not very level and slopes slightly toward one end. This land was selected on account of the leguminous crops (cow-peas), which were growing in plots 7, 8, 9, 10, 13, 14 and 15; such crops being needed in the test as stated in the plan of experiment . This soil is fairly uniform in texture, being light loam. The land was divided into eighteen plots, each plot being ten meters long by four meters wide, containing 1/250 hectare each. The plots were arranged crosswise of the slope, and separated by paths one meter wide.

The check plots were located, two at one end of the field and one at the other end. These unfertilized plots are indicated by a cross(+) in the diagram.

The land had been previously under cultivation with vegetable crops, such as cabbages, egg plants, tomatoes, cow-peas and corn.

The preparation of the land was begun early in the month of September 1915, and lasted till the eighteenth of the same month, the vines of the cow-peas being all worked into the soil.

Application of Fertilizers

On account of the strong *baguios* which swept over this part of the island on the 24th of October, and on the 5th of December, 1915, the application of manures was delayed until December 20th, 1915. The horse manure was somewhat fresh when it was applied to the plots. In order to have a uniform distribution, it was applied broadcast and then forked in and mixed thoroughly with the soil.

The following table shows the kinds of fertilizers used and their calculated amount and value per hectare:

Table IV.

Plot No.	*Kinds of Fertilizers*	*Amount per hectare in kilos*	*Estimated cost per hectare*
1	Horse Manure 30 p. c.	49500.00	₱ 45.00
2	Horse Manure 30 p. c.	49500.00	
	Sulphate of ammonia at ₱.1962 a kilo	168.47	78.05

TABLE IV.—Cont'd.

Plot No.	Kind of Fertilizers	Amount per hectare in kilos	Estimated cost per hectare
3	Control		
4	Horse Manure 30 p. c.	49500.00	
	Sulphate of ammonia	168.47	
	Sulphate of potash	224.63	113.14
5	Horse Manure 30 p. c.	49500.00	
	Sulphate of potash	124.63	80.09
6	Control		
7	Legumes (Cow-peas turned under)		20.00
8	Legumes (same as No. 7)		
	Horse manure 30 p. c.	49500.00	
	Sulphate of potash	224.63	139.24
	Double superphosphates at ₱.1162 a kilo	336.95	
9	Legumes (same as No. 7)		
	Horse manure 30 p. c.	49500.00	
	Sulphate of ammonia	168.47	172.29
	Sulphate of potash	224.63	
	Double superphosphates	336.95	
10	Legumes (same as No. 7)		
	Horse manure 30 p. c.	49500.00	
	Sulphate of potash	224.63	100.09
11	Horse manure 30 p. c.	49500.00	
	Sulphate of potash	224.63	119.24
	Double superphosphates	336.95	
12	Horse Manure 30 p. c.	49500.00	
	Double superphosphates	336.95	84.15
13	Legumes (same as No. 7)		
	Horse manure 30 p. c.	49500.00	
	Sulphate of ammonia	168.95	98.05
14	Legumes (same as No. 7)		
	Horse manure 30 p. c.	49500.00	
	Double superphosphates	336.95	104.15
15	Legumes (same as No. 7)		
	Horse manure 30 p. c.	49500.00	
	Sulphate of ammonia	168.47	133.13
	Sulphate of potash	224.63	
16	Control.		
17	Horse Manure 30 p. c.	49500.00	
	Sulphate of ammonia	168.47	152.29
	Sulphate of potash	224.63	
	Double superphosphates	336.95	
18	Horse Manure 30 p. c.	49500.00	45.00

NOTE: 1 Ha.–2.47 Acres; 1 Kilogram–2.2 lbs. approximately.
1 petroleum can (p.c.) = 6.6 kilograms.
1 cart full of manure contains at least 60 p. c.

The figures in kilos in the above table have been computed from the following formula:

Sulphate of Ammonia.....150 lbs. per Acre.
Superphosphates.....300 " " "
Sulphate of Potash.....200 " " "

The cost of fertilizer given in the second column includes the cost of transportation, which is ₱7 per 6,000 kilos. The cost of manures was based on the prevailing cost of hauling at ₱1.50 a day; four cartloads of manure counting as one day's hauling.

VARIETIES OF TOBACCO USED

The varieties of tobacco used in this work consisted of the five already acclimatized varieties in the College; namely, Turkish Lowland, Vuelta Abajo, Tirona Hybrid, Sumatra and the Texas Cuban. The seeds of the first three varieties were obtained from the selected stock of Miraflores, that of Sumatra was obtained from the selected stock of Consunji, and that of Texas Cuban from the writer's own selected stock of last year.

All of these varieties had been tested on fertilized plots by Dawis and Miraflores of last year's Agronomy III class, and been found to respond well to commercial as well as to natural fertilizers. The same students observed these varieties to show the greatest response to ammonium sulphate and double superphosphates. The latter fertilizer showed better effect on the vegetative growth and yield of the varieties treated.

Transplanting and Subsequent Care

Previous to planting, all the plots were thoroughly cleaned and brought into good tilth. The planting of the seedlings of the different varieties used in this work was carried out in the following manner: First, each plot was marked off into seven rows by thirteen, thus making the total number of plants in a plot ninety-one; the rows being 75 cm. apart and the plants 50 cm. apart in the row. Each plot received five varieties. The first planting (of the first pricked plants) consisted of eight rows, the first row being occupied by the Turkish Lowland, the second third and fourth rows by Sumatra; the fifth by Tirona Hybrid; the sixth and seventh rows by Texas Cuban, and the eighth row by Vuelta Abajo. The second planting (of the second pricked plants) consisted of five rows, the ninth, tenth, and thirteenth rows being occupied by Tirona Hybrid; the eleventh row by Vuelta Abajo, and the twelfth row by Sumatra.

It should be noted that every variety has rows running crosswise of all the plots. The direction and number of each row are indicated by an arrow and Arabic number, respectively, in the diagram. In order to give each variety a chance to reach, at the same time, toward each of the fertilizers applied, an effort was made to plant each row throughout at the same time. It should also be noted that the commercial fertilizers were not applied to the soil at the same time. The manure was applied six days before the planting, since, being somewhat fresh when it was applied, time was necessary for it to decompose.

The transplanting of young plants was begun December 30, 1915. It was done late in the afternoon and also early in the morning. Only strong, stocky, vigorous and uniform plants were selected and planted. They were thoroughly watered just after transplanting and shaded with cut pieces of banana leaf for four days. A few hours previous to removal of the young plants the seed boxes were thoroughly moistened in order that the soil might adhere to the roots of the plants when removed.

Watering was done only once, since the weather for a period of one week after the transplanting was very favorable, being showery and cloudy. The whole field received but two cultivations during the period in which cultivation was possible. This put the soil into a thoroughly good state of tilth.

Diseases and Insect Pests

It was observed that the tobacco plants grown in the field selected for this test were more or less affected with various diseases and insects; namely, mosaic disease, tobacco wilt, physiological defects, black and green cutworms, and small green grasshoppers. About ten days after the transplanting, numerous small green cutworms and grasshoppers appeared, and efforts to gather and destroy them were continued throughout the course of the development of the plants.

Harvesting, Poling and Curing

The harvesting of the tobacco was begun February 17 and lasted until the 22nd of March. The harvesting

was done row by row at the same time, that is, one row of the same variety passing through all of the plots. The leaves taken from each plot were separately weighed and recorded, and then allowed to wilt before being poled. The poling was done by the Cuban methods; that is, the leaves were strung side by side with the thin edges turned in on a pole about two and a half meters long. The poled leaves were then allowed to cure on the curing racks. The first poled leaves were completely cured by March 15. The cured leaves were also weighed carefully so as to get their cured weights, which will be used in the computation of production.

Comparative Results from Fertilized Plots

The test of burning quality of cured leaves of each of the five varieties used was performed as follows: Samples of each variety grown in each plot were sorted out. Then five leaves of each variety from the same plot were tested separately by touching a lighted cigar to the surface of each and the number of seconds of duration of glow was carefully noted. The average of these five readings gives the corresponding reading of a single test for the variety thus tested. The comparative results of the test are shown in Table VII. The average readings given in the last column show that the leaves of tobacco obtained in plot 7 (with legumes alone) give the highest reading, 39.7 seconds, those of plots 3-6-16 (control, come next, those of plot 12 (with horse manure, double superphosphates) the third, and those of plot 14 (with legumes, horse manure, double superphosphates) the lowest, 3.14 seconds.

The separate tests for each variety as shown in the table are so variable that a definite conclusion that a fertilizer consisting of manures, phosphoric acid, and potash, as was found by Olson (page 5) gives the highest effect on the aroma, flavor and burn of the tobacco cannot be given. The writer found during this test that a nitrogenous fertilizer consisting of legumes alone will give these qualities. According to the recorded results it can be noted that the varieties reacted differently. The burning quality of Turkish Lowland was very much improved by legumes alone (Plot 7), by horse manure combined with sulphate of potash, double superphosphates (Plot 11), and by horse manure with double superphosphates (Plot 12); Sumatra was improved by horse manure and sulphate of ammonia combined (Plot 2); Tirona Hybrid and Texas Cuban were improved by horse manure alone and also legumes alone (Plots 7 and 18); and Vuelta Abajo by legumes alone (Plot 7).

During the period of development of the plants an effort was also made to observe their vegetative growth. The plants grown in plots 1, 2, 4, 5, 9, 10, 11 and 17 were all tall, uniform, vigorous, healthy, and well set with long, broad, thick, and dark leaves; while those grown in plots 7, 8, 14 and 15 showed intermediate results. The comparative results thus observed are shown in Table VI.

Using assumed values the gain on the total investment was computed as follows: The computed expenses, excluding the expenses on fertilizers, in the production of the tobacco amounted to ₱57.50. The expenses on each fertilizer was added to this amount, to get the total expenses. The interest on this amount, figured as 2.5% for the time of investment, was added to the total expenses; this gives the total investment. The total investment subtracted from the income gives the gain on the investment. As a result of this test, plot 7 gave the highest percentage

of net gain over the control, which is about 86%, and plot I comes next with a net gain of about 53%.

EXPENSES OF THE FERTILIZATION WORK

Cultivation, harvest, etc	₱ 57.50
Cost of fertilizers (for plot I)	45.00
TOTAL EXPENSES	₱102.50
Interest at 2½%	2.50
TOTAL INVESTMENT	₱105.00
Income	256.86
GAIN ON THE INVESTMENT	₱151.86

TABLE V.

Comparative results of the fertilization on the yield of Tobacco.

Plot No.	Kinds of Fertilizers	Yield of Cured Standard Leaves: Ave. per plant in kilos	Yield of Cured Standard Leaves: Computed yield per Ha. in kilos	Yield of Cured Standard Leaves: Total value of yield per Ha. ₱.1521 per kilo	Computed Investment	Gain on the Investment	Increase of production due to fertilizers over the control: Kilos	Increase of production due to fertilizers over the control: Percentage
1	Horse manure	.06333	1688.758	256.86	105.06	151.80	648.784	62.4
2	Horse manure Sulphate of ammonia	.0628	1674.6248	254.70	138.94	115.76	634.651	61.0
3–6–16	Control	.039	1039.974	158.18	58.94	99.24		
4	Horse manure Sulphate of ammonia Sulphate of potash	.069	1839.954	279.86	174.91	104.96	799.98	76.9
5	Horse manure Sulphate of potash	.060	1599.96	243.35	141.02	102.33	559.986	53.8
7	Legumes	.065	1733.29	263.63	79.44	184.19	693.316	66.6
8	Legumes Horse manure Sulphate of potash Double superphosphates.	.0605	1613.293	245.381	201.66	43.72	573.319	55.1
9	Legumes (Same as No. 7) Horse manure Sulphate of ammonia Sulphate of potash Double superphosphates	.0727	1938.618	294.863	235.53	59.33	898.644	86.4
10	Legumes Horse manure Sulphate of potash	.0734	1957.284	297.702	161.52	136.182	917.310	88.2
11	Horse manure Sulphate of potash Double superphosphates.	.05	1333.30	202.794	181.16	21.63	293.326	28.2
12	Horse manure Double superphosphates.	.0631	1682.624	255.92	145.19	110.73	642.65	61.9
13	Legumes Horse manure Sulphate of ammonia	.067	1786.622	271.745	159.44	112.305	746.648	71.9
14	Legumes Horse manure Double superphosphates.	.055	1466.63	223.074	165.69	61.424	426.656	41.0
15	Legumes Horse manure Sulphate of ammonia Sulphate of potash	.0735	1959.951	298.108	195.41	102.698	919.977	88.5
17	Horse manure Sulphate of ammonia Sulphate of potash Double superphosphates.	.0662	1765.289	268.50	215.03	53.47	725.315	69.7
18	Horse manure	.0481	1282.634	195.088	105.06	90.028	242.66	23.3

NOTE: Average Price in the Municipal Market—₱0.1521 per kilo.—1 Ha.–distance of .75×.50 meters = 26,666 plants.

TABLE VI
Averages of height of plant and size of Leaf

Plot No.	Kinds of Fertilizers	TURKISH LOWLAND			SUMATRA			
		Ave. total height	Leaf		Ave. height	Leaf		Ave. height
			Ave. length	Ave. width		Ave. length	Ave. width	
		cm.	cm.	cm.	cm.	cm.	cm.	cm.
1	Horse manure	157.0	56.64	27.9	157.0	47.7	25.9	160.0
2	Horse manure, sulphate of ammonia	154.8	63.3	31.34	161.0	53.1	31.10	171.5
3-6-16	Control	152.2	49.29	26.18	133.0	40.5	26.34	137.0
4	Horse manure, sulphate of ammonia, sulphate of potash	178.0	60.28	34.92	148.0	49.24	27.20	179.4
5	Horse manure, sulphate of potash	173.5	61.1	28.44	147.5	43.9	25.92	158.2
7	Legumes (cowpeas plowed under)	142.8	50.92	21.82	140.3	43.1	23.5	157.0
8	Legumes, horse manure, sulphate of potash, double superphosphates	141.8	52.42	25.74	148.0	48.0	27.4	168.4
9	Legumes, horse manure, sulphate of ammonia, sulphate of potash	157.0	46.06	25.60	152.7	42.34	26.54	165.0
10	Legumes, horse manure, sulphate of potash	154.6	50.8	25.52	149.4	46.30	23.98	144.0
11	Horse manure, sulphate of potash, double superphosphates	139.	49.6	25.22	137.0	41.72	23.44	141.6
12	Horse manure, double superphosphates	119.6	44.8	25.90	143.0	45.22	24.34	136.0
13	Legumes, horse manure, sulphate of ammonia	142.0	45.04	27.16	143.6	45.20	26.90	143.0
14	Legumes, horse manure, double superphosphates	156.0	50.0	29.12	153.0	48.6	28.86	142.5
15	Legumes, horse manure, sulphate of ammonia, sulphate of potash	148.	46.84	28.62	141.4	43.3	25.26	158.0
17	Horse manure, sulphate of ammonia, sulphate of potash, double superphosphates	137.0	43.6	25.16	142.5	44.8	25.22	151.0
18	Horse manure	120.0	44.44	26.16	144.0	43.9	24.28	135.8

Plot. No.	Kinds of Fertilizers	TIRONA HYBRID			VUELTA ABAJO			TEXAS CUBAN	
		Leaf		Ave. height	Leaf		Ave. height	Leaf	
		Ave. length	Ave. width		Ave. length	Ave. width		Ave. length	Ave. width
		cm.	cm.	cm.	cm.	cm.	cm.	cm.	cm.
1	Horse manure	65.0	32.5	144.6	49.0	29.1	140.	46.5	27.5
2	Horse manure, sulphate of ammonia	68.26	39.0	141.2	47.	28.0	152.3	47.5	30.6
3-6-16	Control	54.16	29.82	119.0	38.2	23.03	128.6	39.4	24.8
4	Horse manure, sulphate of ammonia, sulphate of potash	72.60	40.50	158.0	49.5	31.7	160.0	51.8	29.5
5	Horse manure, sulphate of potash	62.5	34.16	137.4	43.3	29.9	141.0	40.7	24.5
7	Legumes (cowpeas plowed under)	58.4	31.24	122.6	39.4	23.6	106.5	40.5	25.9
8	Legumes, horse manure, sulphate of potash, double superphosphates	70.6	37.80	140.0	47.0	28.1	137.2	46.8	28.
9	Legumes, horse manure, sulphate of ammonia, sulphate of potash	65.54	37.50	148.0	49.0	29.20	159.0	47.	28.3
10	Legumes, horse manure, sulpate of potash	62.6	33.44	153.0	50.4	31.9	155.0	47.2	27.9
11	Horse manure, sulphate of potash, double superphosphates	60.1	33.60	256.0	49.9	10.4	131.6	44.3	27.0
12	Horse manure, double superphosphates	62.0	31.30	139.4	47.6	27.0	131.0	40.5	24.6
13	Legumes, horse manure, sulphate of ammonia	57.7	32.0	120.0	44.4	27.3	143.0	44.6	28.5
14	Legumes, horse manure, double superphosphates	56.2	34.76	135.0	46.6	27.5	131.0	40.0	24.5
15	Legumes, horse manure, sulphate of ammonia; sulphate of potash	60.2	33.60	143.0	49.0	27.3	154.2	49.0	29.3
17	Horse manure, sulphate of ammonia, sulphate of potash, double superphosphates	60.2	31.4	155.8	45.0	27.0	163.0	46.6	26.3
18	Horse manure	56.6	33.74	144.0	45.7	22.0	148.0	43.7	27.5

TABLE VII.

Comparative results of the different fertilizers on the burning quality of the leaves of the varieties used in the test.

Plot No.	Kinds of Fertilizers	*Turkish Lowland*	*Sumatra*	*Tirona Hybrid*	*Texas Cuban*	*Vuelta Abajo*	*Ave. No. of seconds (11) of duration of glow*
		Duration of glow in seconds	*Duration of glow in seconds*	*Duration of glow in seconds*	*Duration of glow in seconds*	*Duration of glow in seconds*	*Duration of glow*
1	Horse manure	8.1	10.0	30.5	28.4	4.0	16.2
2	Horse manure, sulphate of ammonia	19.2	42.8	14.1	9.2	4.0	17.4
3-6-16	Control	19.7	31.4	57.8	31.2	19.0	31.8
4	Horse manure, sulphate of ammonia sulphate of potash	9.8	6.8	9.8	10.0	6.0	8.5
5	Horse manure, sulphate of potash	18.8	5.2	29.0	13.2	10.0	15.24
7	Legumes (cowpeas turned under)	57.1	16.4	81.8	24.4	19.0	39.7
8	Legumes, horse manure, sulphate of potash, double superphosphates	26.1	8.7	3.0	4.3	5.0	9.42
9	Legumes, horse manure, sulphate of ammonia, sulphate of potash, double superphosphates	16.4	6.0	14.5	.8	2.0	7.38
10	Legumes, horse manure, sulphate of potash	21.0	6.0	3.8	6.9	6.8	8.9
11	Horse manure, sulphate of potash, double superphosphates	33.5	5.6	4.8	2.7	4.6	10.2
12	Horse manure, double superphosphates	74.3	9.2	28.0	4.5	7.7	24.9
13	Legumes, horse manure, sulphate of ammonia	9.8	2.2	6.8	2.2	2.9	4.78
14	Legumes, horse manure, double superphosphate	3.1	3.2	4.4	2.4	2.6	3.14
15	Legumes, horse manure, sulphate of ammonia, sulphate of potash	4.2	4.2	4.0	2.2	1.6	3.24
17	Horse manure, sulphate of potash, double superphosphates	1.8	11.8	7.6	9.9	7.4	7.7
18	Horse manure	.9	.8	46.0	38.63	9.1	22.4

CONCLUSIONS

1. Looked at from the standpoint of financial returns, the largest gains were obtained from the use of manure alone (Plot 1) and legumes alone (Plot 7).

2. From the economic standpoint of the Filipino farmer, green manuring, using cowpeas and other leguminous crops, and animal manuring, using horse manure and carabao dung, furnish the cheapest materials for the production of better crops of tobacco.

3. Systematic and careful application of commercial fertilizers should be carried out by every large grower so as to determine the needs of his particular soil.

4. All varieties used in the test showed a creditable response in height, vigor, and to some extent in yield, to the fertilizers applied.

RECOMMENDATIONS

1. More extensive and careful study in the fertilization work is needed; (a) to obtain better production, (b) to determine when the quality of each of the different varieties we have at hand reaches its best, (c) and to some extent, to develop the aroma and flavor of their leaves.

2. In using any fertilizing material, either commercial or natural, with the aim of increasing the yield of the crop in question, the land should be put in its best possible tilth.

3. This work should be repeated in all of the important tobacco growing districts of the Islands.

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The writer desires to express his thanks to Prof. Charles F. Baker for suggestions and help during the progress of this work.

Variability of Tobacco in Cultures on the College Farm

By Alfonzo B. Cagurangan

Thesis presented for graduation from the College of Agriculture No. 57*

Tobacco in cultivation is everywhere a variable plant. While it admits of easy inbreeding, the strains resulting, although pure in the sense of having a single parent, perhaps through a number of generations, are slow to reach the point where they will bred as "true" as many other crops do in the first generation from a single parent. The usual Philippine tobacco field is a truly remarkable mixture of diverse strains. The resulting loss in value of the crop is so serious, but at the same time so easy to remedy in large part, that there is probably no other modification of local practice which would immediately be as profitable as would even such selection as the small scale planter might easily practice.

It is a matter of common observation that the tobacco cultures of Cagayan and Isabela exhibit a serious lack of uniformity and it seems to be the common idea that this is increasing as the years go by. It is a well known fact that in some localities the amount of low grade tobacco produced is increasing, resulting in corresponding losses to the grower. This tendency should be easily checked by repeated and rigorous selection, leading to the isolation and production of purer strains of the most desirable types.

Hybridization may result in the production of highly vigorous strains more peculiarly adapted to certain special purposes than are their parents. This is well illustrated in the case of the Tirona Hybrid produced at the College of Agriculture. An attempt had been made at the College to grow the finer types of foreign wrapper tobaccos and none of these attempt gave promising results. Following this, one of the best wrapper types, the Connecticut Broad Leaf was hybridized with a desirable strain of Cagayan tobacco, this work being done by Mr. Tirona. Out of the many forms which resulted from this cross, certain ones have proven to be of very desirable type, of remarkable vigor, and have produced in culture as fine wrapper leaf, according to expert opinion, as is imported here from Sumatra. It will require active work in selection and repeated testing to purify and thoroughly establish these most desirable strains.

Objects of the Present work

1. To examine all College cultures of the standard tobaccos grown from supposedly pure seed to determine the extent and character of variation in leaves and in habit.

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* The thesis prepared by Mr. Cagurangan is a very careful study of the variation of one hundred picked plants out of a larger number of plantings of tobacco. It is intended to show the respects in which tobacco varies and the extent of variation, and to furnish a basis for subsequent culture of selected strains. In the first respect, it is a thesis the results of which can not be adequately presented without publication of the very extensive tables and numerous photographs presented with the theses The presentation of the full materials would be exceedingly expensive, expensive beyond the means of this journal, and it is doubtful if these statistics and illustrations, useful as they are locally, would be of sufficient general interest to justify the cost. As a presentation of material for selection, this work will develop its interest as the cultures of selected stock are carried through subsequent generations. Their publication in advance would be relatively uninteresting. For these reasons, we limit ourselves here to the publication of extracts from Mr. Cagurangan's thesis, explaining in brief the plans, methods, and most evident and concrete results and conclusions.—E. B. C.

2. To indicate what forms in each variety are most desirable for initial selections.

3. To inbreed the finest types in all varieties for testing in the succeeding season.

The Material Used

There are four different varieties of commercial tobacco which furnished a basis for this investigation. These include three imported varieties—Texas Cuban, Lowland Turkish, Connecticut Havana—the fourth being the locally produced form, Tirona Hybrid, all being represented by selected and inbred seed.

Methods Used

Plants of exceptional and desirable characters in each of the four varieties named above were carefully observed from the beginning. In a given plot several plants from one variety surpassing or differing from all others of the same variety were selected and marked with a wooden label. The tobacco plots were gone over several times seeking for these plants, always bearing in mind that the most marked variety was to be sought for. As the College tobacco plots were comparatively small, only one hundred plants were selected and marked. When nearly mature, that is when they began to form seed heads, the following important characteristics were noted in the field:

1.—Variety name.

2.—The height in centimeters or meters.

3.—The number of leaves.
- (a) Number of sand leaves.
- (b) Number of standard leaves.
- (c) Number of top leaves.

4.—Dimension of leaves.
- (a) First lowest standard.
- (b) Last upper standard.

5.—Form or (drawing) of the average standard.

6—Texture.
- (a) Pubescence
- (b) Gumminess

7.—Color of leaf.
- (a) Green.
- (b) Dark green.
- (c) Light green.

8.—Surface of leaves.
- (a) Hairy.
- (b) Smooth or oily.
- (d) Wavy.

9.—Position of leaves on stem.
- (a) Horizontal.
- (b) Erect.
- (c) Drooping.

10.—Length of Internodes.

(a) In centimeters taken at the 15th from the ground.

In the noting all of these data, care was taken to make the description of each plant complete, thus facilitating comparisons.

In taking the number of the leaves per plant, one or two dead bottom leaves were discarded. The sand leaves were then counted. These sand leaves vary in number from 3 to 5. They are considered to be of some value when properly gathered and handled. The size of the sand leaves is greater than that of the upper or top leaves. Then from about the fifth leaf, depending upon the age of the plants, the standard leaves were counted. These are the most valuable leaves and they vary in number. The last standard must not be less than 30 centimeters in length. So all leaves distinctly less than 30 centimeters in length are counted as top leaves.

The dimension of leaves is an extremely important point to compare in the different varieties and also in the different types. In getting the dimensions, leaves were measured from the tip to the base of the petioles or vice versa; that is not to the stem but a

little off the stem, depending upon whether the petiole was winged or naked. The width was taken at the broadest part. The last standard was measured in the same way. This was done when the leaf matured, since otherwise the dimensions would be useless.

To get the average form of the standards, there is no better way to describe it than to draw the approximate shape and this has been done in the present work. If possible, the best way is to take photos of the standards of the selected plants.

In studying the texture of the leaves of the plant, practically all leaves were examined. The leaf's lamina was pressed between the thumb and middle finger. Another way is to use a hand lens. The leaves were examined on the flat surface above and below and along the margins and veins. If the hairs commonly have brownish knobs on their ends, this signifies the degree of gumminess. The knobs are gum glands.

The color is very easy to examine, as to whether it is green, dark green or light green. Correct sight only is necessary in this judgment. Color determines type more or less, for it varies even when plants are grown side by side and given the same treatment. The character of the surface of the leaves is very easy to note. Again, the hand lens is very necessary to determine the nature of the pubescence, whether simply hairy, long or short, whether coarse or fine. Oily and smooth leaves go together. Some plants have their leaves dry or rough in appearance.

Position of leaves on stems can be shown in two ways; by drawing, or by merely saying erect, horizontal, and drooping, with a full understanding of each term. The last to be noted was the length of the internodes. This was taken after practically all leaves were harvested. The variability of the length of internodes was noted by measuring the 15th internode of every marked plant. These characteristics as noted are shown in the tables.

Those plants which seemed not to possess the ideal characteristics of good plants were discarded and not allowed to flower. Undesirable plants which have very wavy and very narrow pointed leaves were not allowed to flower. The plants which were fair, approaching the accepted ideal, were saved for general stock. Those plants which were very exceptional were selected, inbred and given culture numbers. They are 27 in all.

Variety	*Average number of leaves*			*Ave. length and width of lowest standard*		*Ave. length and width of topmost standard*		*Average height*	*Average length of internodes*
	Sand	*Standard*	*Top*	*Length*	*Width*	*Length*	*Width*		
Texas Cuban.....	3.75	18.75	3.25	31.25	18.08	26.2	12.45	116.3	3.88
Conn. Havana.....	3.29	18.55	3.12	42.94	25.15	34.27	15.20	145.44	5.89
Tirona Hybrid.....	3.52	19.12	3.43	49.45	27.56	37.86	15.10	135.74	5.69

The above table shows the averages of the most important characteristics. Referring to this table it may be noted that Connecticut Havana is the tallest, being 145.44 cm., next coming Tirona Hybrid, and third, Texas Cuban. In the average number of standard leaves, Tirona Hybrid has the most, 19.12, Texas Cuban the second, and Connecticut Havana the third. In the average length and width of lowest standard, Tirona Hybrid has the longest, 49.45 cm. in length and 27.56 cm. in width. In average length of topmost standard Tirona has the longest, being 37.86 cm. In its width, it is second to Connecticut Havana but in length, Connecticut Havana is second. In the average

length of internodes, Connecticut Havana has the longest, being 5.89 cm., Tirona Hybrid the second, and Texas Cuban the third.

Referring to the tables of individual records the following figures taken from all varieties show something of a correlation between length of internode and number of standards produced:

Number of Standards.	Length of Internodes.
10	6.1 cm.
11	6.2 "
12	6.5 "
13	7.0 "
14	6.1 "
15	6.4 "
16	5.8 "
17	6.1 "
18	5.2 "
19	5.3 "
20	5.8 "
21	4.8 "
22	5.2 "
23	5.2 "
24	5.9 "
25	5.1 "
26	4.6 "
28	5.2 "
31	6.2 "
35	4.9 "
36	4.5 "
40	4.3 "

In looking over these figures, the range of variation as to the number of standards appears to be very great, running from 10 to 40. The figures are deduced in this way: plants having different lengths of internodes but the same number of standard leaves are put together. The lengths of the internodes are averaged together and the result is the corresponding average internode length for the plants having that number of standard leaves.

Compelling Inbreeding by Bagging the Flowers

Bagging is a very simple operation, still most farmers are not well acquainted with it. Manila paper bags are recommended as they are light. This lightness is desirable because if the paper is heavy, the seed head may be bent, the result of which may be undeveloped seed capsules.

At the time when the seed heads begin to bear flowers and before any flowers have opened, bagging must be begun. The bag should be tied so tight as to allow no passage of insects. Leave space within the bag for the normal growth of the seed head. After two or three days change the position of the bags so that the further growth of the seed heads may not be interfered with. Do this until all or most of the capsules are formed. In about 10 to 15 days the bags can be removed so that the capsules may ripen in the open air. When the capsules show maturity, they should be cut and properly labeled. Only 27 types were bagged for the present initial selections.

Seed heads after cutting were placed in a new Manila paper bag and dried hanging in the sun. As soon as the seed heads were dried, the seeds were separated and put into air-tight bottles.

After finishing each lot the hands were washed so that the seeds adhering to the skin or hidden under the finger nails might not be mixed with other varieties or strains of seed.

Strains Best Suited for Cultures

Among the 27 plants selected as types some have their leaves erect, that is they rise at an angle of 30° to 60° with the stem; some have their leaves drooping, but most have their leaves placed horizontally.

Some authors claim that erect leaves permit easier cultivation and picking

of worms, but that the yield is lowered. The horizontally placed leaves will not permit easy cultivation but the yield is said to be greater. Besides, the lower leaves are thinner on account of the effect of shade. This is important for wrapper.

The ideal plant must be marked in the field, that is, the plant which surpasses all others, or approaches the ideal, in number of standards—quality of leaves, shape or leaves, character of veins, etc. The surface of the leaves should be smooth, and the texture fine. The internodes should be short. The length of internodes is related to the number of standard leaves, for the shorter the internodes the more of standard leaves are found. Only those plants which, while given the same treatment, surpass or differ from all others in the same field are to be selected. In judging the characters of a plant, its purpose—for filler, binder or wrapper—should be kept constantly in mind.

Recommendations

1.—That all of the 27 isolated types be tested in head-to-row tests.

2.—That if some of these types break up, repeated selections be made.

3.—That the seeds of these be not distributed until they will breed true.

4.—That all monstrosities which appear be not allowed to flower.

5.—That isolation of good types of tobacco by inbreeding for the establishment of pure strains should be extensively practiced in all the important tobacco regions of the Islands.

Conclusions

From the results, as shown in the tables of individual characteristics and in the photos of the 27 isolated types of tobacco, the following can be concluded:

1.—That different varieties in our cultures exhibit wide variation within themselves, in leaf character and in habit, although the Texas Cuban and Connecticut Havana were supposedly pure strains.

2.—That forms of Tirona Hybrid have the most and the largest standard leaves.

3.—That Connecticut Havana has the tallest forms.

4.—That forms of Tirona Hybrid have the longest internodes.

5.—That in the 100 plants of all varieties described, the range of variation in number of standard leaves is from 10 to 40.

6.—That Connecticut Havana has the smallest extreme number of standard leaves, this being 10, and Tirona the highest, this being 40.

7.—That among all the varieties, the Connecticut Havana forms showed the widest variation. Out of 27 types isolated, 14 were Connecticut Havana.

8.—That Tirona Hybrid in the 13 remaining types shows the widest variation and the sharpest delimination of characters.

9.—That some of the Connecticut Havana forms are especially good for cigar wrapper, due to the fineness and the shape of the leaves.

10.—That some of the best types of Tirona Hybrid show a leaf form and quality admirably adapted to wrappers.

11.—That some of the Tirona Hybrid forms have a leaf form and quality which indicate their usefulness for binders and fillers.

12.—That one very remarkable type of Tirona Hybrid, very tall and vigorous, bearing 40 standards, can hardly be considered other than a "sport."

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